AN INVESTIGATION OF BONE MINERAL DENSITY AND BONE MINERAL CONTENT AMONG HISPANIC WOMEN BY LIFESTYLE FACTORS.

A thesis
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ABSTRACT

Osteoporosis is a disease of the bone characterized by reduced bone mass, deterioration of bone structure, increased bone fragility, and an increased risk of fracture. Known factors that can cause an increase in bone loss include, but are not limited to, calcium deficiency and smoking. Most of the data collected regarding osteoporosis has been referenced to non-Hispanic white women. In the past, few studies were targeted on the ethnic propensity for osteoporosis among women. In recent years, osteoporosis has become an increased concern for Hispanic women. Osteoporosis can be measured partly through bone mass or bone density. The chosen method for measuring bone density is with dual energy x-ray absorptiometry (DEXA). This study, using DEXA results recently released as a part of the National Health and Nutrition Examination Survey (NHANES), looks at the relationship between Hispanic women's calcium consumption and smoking with regard to their bone mineral content (BMC) and bone mineral density (BMD), as measured by DEXA. Data collected from the NHANES database include calcium intake from the dietary intake interview, smoking responses from the smoking questionnaire, and BMC and BMD data from the patient's DEXA scan. From the results we can conclude that smoking decreases BMC and BMD and smoking cessation can help improve BMC and BMD in both Hispanic and overall women in this study. This study also demonstrates that a higher intake of calcium can lead to a higher BMD for women in this study; this finding is more evident in this study for Hispanic women. This study will assist the medical community associated with Hispanic women and allow for more findings for osteoporosis.

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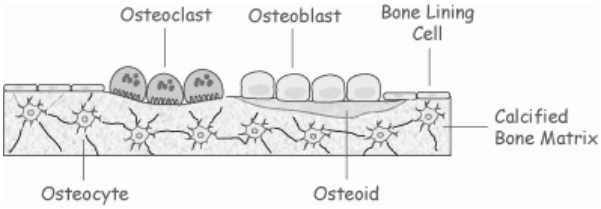
CHAPTER 1

PROBLEM STATEMENT

Osteoporosis is a disease involving the bones. Bones are a support tissue of the body that are highly specialized. Bones provide structural support, protect vital organs, provide an environment for bone marrow, and act as a mineral reservoir for calcium. Bones are composed of osteoblasts and osteocytes (support cells), osteoclasts (remodeling cells), osteoid cells that are composed of a nonmineral collagen matrix and noncollagenous proteins, and inorganic mineral salts, such as calcium, that are found within the matrix, see Figure 1 (International Osteoporosis Foundation, 2007). The "collagen matrix is filled in by bone mineral, or hydroxyapatite, made up of 50 percent phosphate, 40 percent calcium and 10 percent carbonate" (Sterling, 2000).

Figure 1: Basic Bone Biology

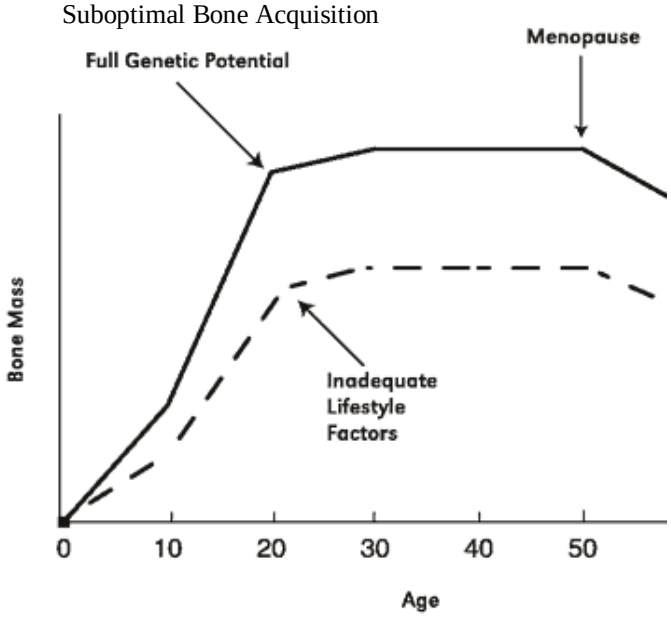


Osteoporosis is a disease characterized by reduced bone mass, deterioration of bone structure, increased bone fragility, and an increased risk of fracture (Hernandez-Rauda and Martinez-Garcia, 2004). Osteoporosis can be measured partly through bone mass or bone density. In 1991 and in 1993 the National Osteoporosis Foundation, European Foundation for Osteoporosis and Bone Disease, and the National Institute of Arthritis and Musculoskeletal and Skin Diseases established a definition for osteoporosis, stating that it is "a systemic skeletal disease, characterized by low bone mass and microarchitectural deterioration of bone tissue with a consequent increase in bone fragility and susceptibility to fracture" (Bonnick and Lewis, 2006, p. 258). Before this definition, many people believed that this was an age-related disease meaning that age was the only factor in acquiring this disorder and that there was no definite way to prevent it. At the 2000 National Institutes of Health (NIH) Consensus Conference,

osteoporosis was defined as a "skeletal disorder characterized by compromised bone strength predisposing to an increased risk of fracture" (Bonnick and Lewis, 2006, p. 261). Bone strength is characterized by both bone density and bone quality; which also includes bone architecture, turnover, microfractures, and mineralization.

Peak bone density is the maximum bone mass or bone density reached in life, as seen in Figure 2 (Carmona, 2004). Everything that hinders development of this peak bone density places an individual at an increased risk for osteoporosis. After this peak bone mass is reached a cycle of osteoblast and osteoclast activity maintains the bone density. Osteoclasts excavate old bone and osteoblasts replace those cells in order to replace the bone that was removed. If these processes are not balanced, bone loss will occur.

Figure 2: Bone Mass versus Age with Optimal and Suboptimal Bone Acquisition



As people age, restructuring of the bone occurs daily leading to an unavoidable loss of bone. Bone development and growth is referred to as osteogenesis. Bone remodeling is the replacement of old bone tissue with new bone tissue; this occurs in adults to maintain bone density. Resorption is the digestion of old bone; this is done by the osteoclasts. If there is "excessive resorption, bones weaken (osteopenia) and over time can become brittle and prone to fracture (osteoporosis)" (International Osteoporosis Foundation, 2007). The balance of osteoclasts and osteoblasts determines if bone is made, lost, or maintained.

"Bone remodeling is controlled by several factors including hormones, physical stress and the availability of building blocks such as calcium" (Sterling, 2000). Known factors that can cause an imbalance in osteoclasts and osteoblasts include, but are not limited to, calcium deficiency, smoking, estrogen deficiency, testosterone deficiency, hyperthyroidism, malabsorption, and use of corticosteroids (Bonnick and Lewis, 2006, p. 265).

Most of the data collected regarding osteoporosis has been referenced to non-Hispanic white women. In the past, few studies were targeted on the ethnic propensity for osteoporosis among women. In recent years, osteoporosis has become a concern for Hispanic women. "The prevalence of osteoporosis in Hispanic women is similar to that found in White women, and the incidence of hip fractures among Hispanic women in California appears to be on the rise" (Carmona, 2004). According to the National Health and Nutrition Examination Survey (NHANES) from 1988-1994, 17% of non-Hispanic white women over the age of 50 were diagnosed with osteoporosis and 42% were diagnosed with osteopenia. Among Mexican American women over the age of 50, 12% were diagnosed with osteoporosis and 37% were diagnosed with osteopenia. The diagnosis of osteoporosis and osteopenia between non-Hispanic white women and Mexican American women appears to be similar (National Center for Health Statistics, 2008). The increasing prevalence of this disease among Hispanic women has been the motivation for this study to discover their risk factors. "Hispanics are now the largest minority group in the United States, comprising 12.5% of the population," according to the 2000 US census (Yarbrough et. al., 2004, p. 93). With the number of Hispanics living in the United States increasing, there becomes an increasing need for health research in this population. The relationship between Hispanic women's calcium consumption and smoking with regards to their bone mineral density (BMD) and bone mineral content (BMC) is the primary focus of this study.

The chosen method for measuring BMD and BMC is with dual energy x-ray absorptiometry (DEXA). DEXA or bone densitometry is a form of x-ray technology used to measure bone loss. The DEXA unit uses low-dose x-rays to penetrate both soft tissue and bone. These two structures have two different energy peaks that are used to calculate BMD and BMC. According to Bonnick and Lewis, "X-ray densitometers ultimately report bone mineral density (BMD), none actually measure BMD" (Bonnick and Lewis, 2006, p. 8). The actual quantities measured are BMC and length or area of the bone. A formula is used to calculate the BMD: BMC (g)/Area (cm^2) = BMD (g/cm^2) (Bonnick and Lewis, 2006, p. 9). "DEXA is today's established standard for measuring bone mineral density (BMD)" (Radiological Society of North America, Inc, 2006). The typical sites for DEXA measurement are at the spine, hip, forearm, and total body.

In 1994 the World Health Organization (WHO) set up guidelines to allow them to estimate the prevalence of osteoporosis in individuals in different countries. Different levels of bone density were established, ranking patients from normal to severe (established) osteoporosis as shown in Table 1. The T-scores seen in Table 1 indicate the number of standard deviations (SDs) above or below the average peak bone density (Bonnick & Lewis, 2006, p. 260-261). The T-score is what clinicians use to diagnosis osteoporosis.

Table 1

World Health Organization (WHO) Criteria for the Diagnosis of Osteoporosis Based on the Measurement of Bone Density

Diagnosis	Bone Density Criteria	T-score Criteria
Normal	Not more than 1 SD below the average peak young adult value	Better than or equal to -1
Osteopenia (low bone mass)	More than 1 but not yet 2.5 SDs below the average peak young adult value	Poorer than -1 but better than -2.5
Osteoporosis	2.5 SDs or more below the average peak young adult value	-2.5 or poorer
Severe (established) osteoporosis	2.5 SDs or more below the average peak young adult value + a fracture	-2.5 or poorer + a fracture

REVIEW OF LITERATURE

Calcium is a mineral that is important in the human body. "About 99 percent of the calcium in our bodies is found in our bones and teeth" (National Osteoporosis Foundation, 2008). Calcium also allows blood to clot, nerves to send messages, and muscles to contract. Calcium is lost from our bodies daily; since the human body cannot produce calcium it is important to have calcium in one's diet. Calcium is absorbed from the foods we eat by the gastrointestinal tract. This absorption is regulated by vitamin D and parathyroid hormones (Environmed Research Inc., 1995). It is also necessary for there to be an adequate amount of vitamin D in one's diet to help with calcium absorption. Calcium deficiencies can be a result of numerous factors including vitamin D deficiency and smoking. When there is a calcium deficiency in the bones, there is an increased chance of osteoporosis. During growth the calcium is deposited into the bones. Since the bone matrix is composed of about 40 percent calcium it is important for there to be an adequate amount of calcium in a person's diet to ensure proper bone

development and remodeling. Dietary calcium is mainly absorbed by the bones in childhood and adolescence. During this time it is important to reach the peak bone mass to help prevent loss of BMD later in life. As indicated by U.S. government food surveys, "most children older than five, adolescents and adults do not get enough calcium" (Sterling, 2000). Education about osteoporosis is a major step toward prevention of this disease. The following studies address topics relating calcium intake and its relationship to osteoporosis.

A survey designed by Larkey, Hoelscher Day, Houtkooper, and Renger in 2003, was intended to collect information that would ultimately assist in the development of osteoporosis prevention education materials as well as marketing strategies. They specifically looked at age and ethnicity factors related to both Hispanic women and non-Hispanic white women by means of a telephone survey (n=200). Questions regarding the amount of calcium consumption were asked and the questions assessed the level of knowledge that each woman had regarding osteoporosis. This study looked at multiple sources of calcium in an average diet including milk products, green leafy vegetables, soy, beans, and corn tortillas. It was revealed that 83% of women knew that calcium intake is important (Larkey et. al., 2003). This study also showed that Hispanic women were less likely to consume milk products as a source for calcium; however, they were more likely to consume products like corn tortillas and beans when compared to non-Hispanic white women. A recent study in 2004 performed by Yarbrough, Williams, and Allen on osteoporosis in Hispanic women states, "the Hispanic population in the United States consumes lower intakes of calcium due to lactose intolerance" (Yarbrough et. al., 2004, p. 97). The study by Larkey et. al. (2003) concluded that more education about osteoporosis needs to be provided to all women regardless of race. More education is necessary to teach women the risks of osteoporosis and ways to help prevent it, such as increasing one's calcium intake.

Although this 2003 study found answers regarding knowledge of osteoporosis prevention, it did not look into areas surrounding the correlation of calcium consumption with osteoporosis. A person's knowledge does not always translate into her actions. This study was based on a convenience sample of 200 women and although there was some diversity in this study, the nature of the sample limited the ability to generalize to a larger population. Since the data was collected with a telephone survey, people of low income households who do not have a phone were not included in the sample. Other variables such as income or location could play a part in health care accessibility. The study of Hispanic women and other women of ethnicity needs to be expanded to determine the unique issues related to their risk for osteoporosis.

A study done by Kalkwarf, Khoury, and Lanphear in 2003, determined that milk intake at the time of childhood and adolescence was associated with adult bone mass, BMD, and the occurrence of osteoporotic fracture. The study sample consisted of 3,251 non-Hispanic white women who were asked about their milk consumption during childhood, adolescence, and the present. The result of the study showed that low intake of milk during childhood was associated with a 2-fold greater risk for fracture (Kalkwarf et. al., 2003). Children with a higher calcium intake have been known to increase their peak bone mass thereby reducing their chance of osteoporosis.

This 2003 study by Kalkwarf et. al. had a large sample size and it helped prove that milk intake during childhood assists in preventing a loss of bone mass and reducing the risk of fracture for non-Hispanic white women. A limitation to this study is that the participants were asked about their milk consumption during childhood, adolescence, and present time. These statistics may not be accurate due to faulty memory. A study that measured calcium intake over time would be a more accurate study. Due to the known racial and ethnic differences in BMD

and risk of osteoporosis, the sample was restricted to non-Hispanic white women which limited the generalizability of this study to Hispanic women. More diversity should be included in the study because of these known differences; data on osteoporosis needs to be specific to each minority group. Milk consumption was the focus on this study and although they accounted for supplements, alternate forms of calcium intake should be considered.

An article by Evans and Taylor in 2006 addresses Hispanic women's risk for osteoporosis and studies them based on an ecological approach to determine risk factors associated to this disease. A secondary data analysis was performed based on data collected from the NHANES data set. There were 413 Hispanic women ages 60 and older in this study. An ecological research model was used to evaluate aspects such as financial support, smoking, milk consumption, and self-reported measures of osteoporosis. Evans and Taylor (2006) found an increased prevalence of osteoporosis diagnosis in older Hispanic women who preferred the Spanish language, had decreased emotional support, increased financial support, owned their home, and had consumed milk. A second finding indicated an increase in self-reported fractures among older Hispanic women who preferred the Spanish language, had decreased emotional support, increased financial support, and had not smoked. Evans and Taylor (2006) conclude that ecological factors should be considered when making decisions about screening for diseases and for preventative health education among older Hispanic women.

This 2006 study by Evans and Taylor addresses the importance for research on minority populations. Although the sample size of 413 Hispanic women is small, they were able to generalize the data to 2.2 million United States residents. This study addresses milk consumption, not calcium consumption; an additional study looking at calcium consumption would be helpful since not all women drink milk as a source of calcium. Another limitation seen

is the self-reported measure of osteoporosis and fractures. Evans and Taylor (2006) state "NHANES bone density data may be a more objective measure of osteoporosis than 2 models that have differing ecological characteristics based on self-reports" (Evans and Taylor, 2006, p. 458). Another study should be done using NHANES bone density data to assess osteoporosis in older Hispanic women.

Smoking has many adverse effects on the human body. Smoking causes a decrease in BMD and also decreases calcium absorption. This loss of BMD and decreased calcium absorption can increase the likelihood of being diagnosed with osteoporosis (Office of Dietary Supplements National Institutes of Health, 2008; National Osteoporosis Foundation, 2008). Smoking also leads to an increased fracture rate. The Hispanic population is increasing in the United States. With this increase there has been acculturation or changes in beliefs, values, and behaviors as a result of interaction with people of a different ethnic group (Bethel et. al., 2005, p. 143). Hispanics have adopted the smoking "norms" of the United States. We can see this when looking at the trends of smoking initiation and weekly smoking. According to a 2004 study on racial disparities in smoking by Ellickson, Orlando, Tucker, and Klein, "by the age of 13 years, nearly 70% of Hispanic youths… had started smoking" (Ellickson et. al., 2004, p. 295). This study also concluded that Hispanics and Whites are "significantly more likely to be weekly smokers" than other races (Ellickson et. al., 2004, p. 295). According to the Center for Disease Control and Prevention (CDC), in 2006 19.1% of white Americans over the age of 18 are smokers, 10.5% of Hispanics or Latinos are smokers, and 9.5% of Mexican Americans are smokers. They also found that those over the age of 65 were less likely to smoke with only 8.5% of white Americans and 5.6% of Hispanics or Latinos being current smokers. Smoking cessation

has been shown to have a beneficial effect on limiting bone loss (Hollenbach et. al., 1993). The following studies show the relationship between smoking and osteoporosis.

The relationship between smoking and BMD was examined by Rapuri, Gallagher, Balhorn, and Ryschon in a 2000 study of 444 women aged 65-77 years. Each woman was provided with a questionnaire that asked about smoking and alcohol history. In addition each woman had to complete a dietary intake diary for seven days to obtain an average calcium intake in their diet. DEXA was used to measure BMD. The data examined the relationship between BMD and smoking. The results showed that smoking decreased BMD in postmenopausal women by 13 percent when compared to non-smokers. This was a result of decreased calcium absorption and increased bone resorption (Rapuri et. al., 2000, p. 429). This study illustrated a correlation between smoking and osteoporosis.

A limitation in this study by Rapuri et. al. (2000) is the self reported history of smoking and alcohol use. Relying on one's memory and honesty is not the most accurate form of data collection. This study had a limited sample size; however it showed a vital link between smoking and osteoporosis. This correlation may be true for postmenopausal elderly women, but it is difficult to generalize this to other women, specifically Hispanic women.

A cohort study performed by Hollenbach, Barrett-Connor, Edelstein, and Holbrook in 1993, looked at the association between cigarette smoking and BMD. They collected data at two points in time 16 years apart on 544 men and 822 women by a standard interview. The sample consisted of predominantly white, upper-middle class, elderly men and women. This analysis found that men and women who smoke have an increased risk of bone loss and reduced BMD which may cause an increase in fractures later in life (Hollenbach et. al., 1993). Hollenbach et.

al. (1993) concluded that quitting smoking may have a positive effect on limiting the bone loss caused by smoking.

Although this 1993 cohort by Hollenbach et. al. had findings that were conclusive for white, upper-middle class, elderly men and women; it is difficult to say if similar results would be found among Hispanic women. Diversity needs to be addressed when conducting studies related to smoking and osteoporosis, specifically with reference to Hispanic women.

A 2005 meta-analysis study, done by Kanis, Johnell, Oden, Johansson, Laet, Eisman, Fujiwara, Kroger, McCloskey, Mellstrom, Melton, Pols, Reeve, Silman, and Tenenhouse, looked at ten different cohorts to examine smoking as a risk factor for future fractures. A meta-analysis is the highest level of evidence based information on this subject. The study sample, 59,232 international men and women, were asked if they currently smoke, have ever smoked or have never smoked. Across the studies, it was found that the prevalence of smoking decreased with age in both men and women. The study concluded that a history of smoking was associated with an increase in fractures, specifically those related to osteoporosis or hip fracture.

This study was internationally based and had good generalizability due to the large sample size; however, it was not categorized by race so it is difficult to know if this will hold true specifically for Hispanic women. Each ethnicity has its differences and should be looked at independently. Kanis et. al. (2005) acknowledged that other studies are necessary to relate alternate risk factors for osteoporotic fractures. This study looks at three categories of smoking, current smoker, past smoker, and never smoked. These are good areas to look at but there are other ways to categorize smoking, such as number of cigarettes smoked or years of smoking, that may lead to more in-depth results.

OBJECTIVES

A gap exists in the literature related to the assessment of Hispanic women's prevalence for low BMD and BMC with associated osteoporosis. This secondary analysis of a national data base would allow for a more rigorous study to be staged related to this question. This study is based on the article written by Evans and Taylor in 2006, but will use quantitative DEXA data. The research questions for this study are the following:

- What are the BMD and BMC among a group of Hispanic women who have had a total body DEXA?
- What is the relationship between Hispanic women's calcium consumption with regard to their BMD and BMC, as measured with DEXA?
- What are the differences between BMD and BMC, as measured by DEXA, based on smoking status?

CHAPTER 2

METHODOLOGY

The research questions were answered through completion of a secondary data analysis of the recently released DEXA results of participants that contributed health data as part of NHANES. The data collected was from three separate surveys during the period from 1999 to 2004. NHANES is a part of the National Center for Health Statistics (NCHS) and the CDC. NHANES assesses the health and nutritional status of adults and children in the United States. NHANES began conducting studies in the United States in 1960, but they did not become continuous until 1999. The goal of NHANES is to produce a nationally representative sample of people in the United States while still having a manageable sample. NHANES has a nationally representative sample of all ages; oversampling of the elderly, Hispanics, and African Americans was done to produce reliable statistics, and to provide additional data for populations that are typically hard to represent in research studies. NHANES has randomly selected people for the study based on primary sampling units (PSU's) that are based off of geographic divisions where households are selected at random. In the NHANES surveys, each participant, in theory, represents 50,000 other U.S. residents (National Center for Health Statistics, 2008). Since the data sets have smaller samples, data can be combined over several years and can provide more adequate estimations. The survey contains demographic, socioeconomic, dietary, and health related questions.

POPULATION AND SAMPLE

The NHANES data files provided for public use contain several health measures from a large group of subjects. A total of 31,126 people were included in the NHANES data for smoking and calcium intake. From this sample, the participants were limited to those aged 60

and older, leaving 5,607 people remaining in the sample. The sample was then restricted to those people 60 years and older with a BMD equal to or greater than zero, included were 4,792 participants. The sample was then narrowed down further including those ages 60 and older, with a BMD equal to or greater than zero, who were female, resulting in a total of 2,440. The data was restricted again to allow for results specific to Hispanic women. In this study there were 595 Hispanic women over the age of 60 with a BMD equal to or greater than zero. Hispanic women are listed as both Mexican American and Other Hispanic in the NHANES data, and were combined. Due to the oversampling of Hispanic women and the elderly by NHANES, the sample would need to be weighted in order to generalize the results to the United States population.

DESIGN

The variables were chosen because in recent years, osteoporosis has become an increased concern for Hispanic women due to the increased population of Hispanics in the United States (Yarbrough et. al., 2004, p. 97). The independent variables are calcium consumption and smoking. The dependent variables are the total body DEXA results presented as BMD and BMC from the NHANES database. Calcium consumption is important because calcium plays a major role in bone structure and a decrease of calcium in the bones can lead to osteoporosis. Smoking can lead to a decreased calcium absorption rate and a lower BMD, these can both lead to an increased risk of developing osteoporosis. The Statistical Package for the Social Sciences (SPSS) version 17.0 was used for analysis of the NHANES data. An analysis of variance (ANOVA) was run to compare smoking status with BMD and BMC. A Tukey Post HOC test was done to see differences in BMD and BMC between each of the three smoking groups. A Pearson correlation was used to determine the strength of association between calcium intake

and BMD and BMC. T-tests were used to compare the mean BMD and BMC with calcium intake. The sample is representative of a population and the statistical significance is set at a priori of 0.05.

DATA AND INSTRUMENTATION

Data collected from the NHANES database include calcium from the dietary intake interview, smoking responses from a questionnaire, and BMD and BMC data from a DEXA scan. A DEXA scan was performed on NHANES participants over the age of 8 who had a negative pregnancy test at the time of the exam. Participants were also excluded for other reasons such as a self-reported history of radiographic contrast material (barium) use in past seven days, a self-reported history of nuclear medicine study in the past 3 days, or a self-reported weight over 300 pounds or height over 6'5'' (DEXA table limit). The DEXA scan was performed as a total body scan. The low-dose x-rays were absorbed differently throughout the body and what passed through the body is measured by DEXA. NHANES provided DEXA results given as BMC, measured in grams (g), and BMD, measured in grams per centimeter squared (g/cm^2) rather than the standard T-scores used to diagnosis osteoporosis. The DEXA data was inputted into a datasheet in SPSS that contained all the demographic and socioeconomic data from each of the participants. The smoking data was then merged into the DEXA dataset to form a main dataset; the variables were matched by sequence number so that the information for each participant would transfer accurately.

Smoking data was collected from a questionnaire given to each of the participants. The questions were asked so that a numeric answer was given, with designated answers for "refused" and "don't know" to minimize the number of non-response answers. The questionnaires each contained a codebook which can be accessed by the public from the National Center for Health

Statistics website NHANES link (http://www.cdc.gov/nchs/nhanes.htm). The smoking codebooks were compared for each of the three years. Data that was relevant to the present study was matched and if the question labels corresponded in all three surveys, the question numbers were recoded in order to more accurately analyze the data, see Appendix A. After comparison of the questions, the data from each of the individual surveys was inserted into an SPSS datasheet for statistical evaluation. Each smoking dataset was individually compared to its corresponding codebook to ensure that no errors were made when entering the data. Once it was confirmed that each dataset was free of error, the datasets were merged into one larger dataset with the information from all three surveys. A smoker category was formed based on the responses to questions SM20: "Have you smoked at least 100 cigarettes in your life?" and SM40: "Do you now smoke cigarettes?". Smoking status was broken down into three subgroups, never smoker, nonsmoker, and current smoker. These three variables were then used in the data analysis to measure smoking status. Following the merge of the smoking datasets into the main dataset, data from calcium intake was collected.

Food intake was recorded over a 24 hour period for each participant. The objective of this dietary interview was to obtain dietary intake information for the participant and estimate the total intake of energy, nutrients, and non-nutrient food components from what the participant consumed in the 24 hour period prior to the interview (National Center for Health Statistics, 2008). Each participant was interviewed and asked to record the food and beverage items, and the amount of each item, that they consumed in the 24 hour time period along with the amount. The list of foods was checked multiple times to ensure that the participant had not forgotten anything; a post-dietary recall questionnaire was given to the participant after the 24 hour recall. This was done to ensure the accuracy of each participant and to decrease memory errors. Based

on the type and amount of food or beverage listed a value was listed for vitamins and minerals, including the amount of calcium. The calcium amount in each meal was recorded and totaled at the end of the 24 hour period. The amount of calcium consumed by each participant in the 24 hour period was recorded in milligrams (mg). From this value the percent daily intake of calcium was calculated and it was determined whether or not the participant met the daily intake requirements for calcium, see Table 2. According to the Office of Dietary Supplements, the adequate intake (AI) of calcium for children ages 9-18 is 1,300mg per day, for a person 19-50 years of age is 1,000mg per day, and for persons 51 and older the AI of calcium is 1200mg per day (Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, 1997; Office of Dietary Supplements National Institutes of Health, 2008). These results were merged into the main dataset and again sorted by sequence number.

Table 2
Dietary Calcium Intake compared to Adequate Intake (AI)

Respondent Sequence Number	Participant's Age	Recommended Adequate Intake (mg)	Measured Calcium (mg)	Percent intake of Calcium	Did they meet the Daily Requirements for Calcium?
1861	67	1200mg	9mg	0.79%	Not meet Calcium (mg)
15349	70	1200mg	1848mg	154.00%	Met Calcium (mg)
25677	62	1200mg	1190mg	99.17%	Not meet Calcium (mg)

With the merger of the DEXA, smoking, and calcium datasets into one main dataset the data were able to be analyzed using SPSS. The variables were matched by sequence number to ensure that all of the data transferred properly. The data were then narrowed by parameters relevant to this study and results were obtained after running statistics with SPSS.

CHAPTER 3

RESULTS

Correlations were run on Hispanic women regarding BMD, BMC, smoking and calcium consumption. The same correlations were run for the overall total women in this study and were titled "all women" in the data, see Table 3. The correlations were compared between the two groups. Results found for the total women (n=2,240) and Hispanic women (n=595) are presented. There are 595 Hispanic women in this study, approximately 24.4% of the total women over 60 with a BMD equal to or greater than zero. This percent dropped to 7.6% of the total after weighting the sample to better represent the total proportion of Hispanics in the United States. With the weighted sample there is more generalizability of the results.

Smoking status in relation to BMC and BMD was a primary focus for this study. Smoking status for the overall women in this study was 61% never smoked, 29.7% smoked previously and quit, and 9.4% currently smoke. Smoking status for Hispanic women in this study was 66.7% never smoked, 25.1% smoked previously and quit, and 8.2% currently smoke. When comparing the mean BMC and BMD by smoking status for Hispanic women in this study, nonsmokers, those who quit smoking, had a higher mean BMC and BMD (1680 and .9606 respectively) than those who had never smoked (1677 and .9595) and those who were current smokers (1666 and .9573), see Table 3.

Table 3

Descriptives: Smoking and BMC, BMD

		Hispanic Women*			All Women*		
		N	Mean	Standard Deviation	N	Mean	Standard Deviation
Total Bone Mineral Content (g)	Never Smoker	396	1677.1701	326.28854	1440	1835.7098	338.88148
	Nonsmoker	149	1680.3162	347.02673	747	1852.6617	382.48801
	Current Smoker	49	1666.3820	360.95006	250	1779.9579	347.81773
	Total	594	1677.0693	333.96158	2436	1835.1852	354.13643
Total Bone Mineral Density (g/cm^2)	Never Smoker	396	.9595	.10732	1440	.9949	.10877
	Nonsmoker	149	.9606	.11795	747	.9978	.12144
	Current Smoker	49	.9573	.10882	250	.9675	.10832
	Total	594	.9596	.11002	2436	.9930	.11305

Note: * Hispanic women and all women in this study

Mean plots were also run to see the difference in means for BMC and BMD of each group of smokers in both Hispanic women and overall women in this study, see Figures 3-6. For Hispanic women, the plots show that never smokers and nonsmokers have a higher BMC and BMD than current smokers. The same can be seen in this study for the group of total women, never smokers and nonsmokers have a higher BMC and BMD than current smokers.

Figure 3: Mean BMC and Smoking Status in Hispanic Women*

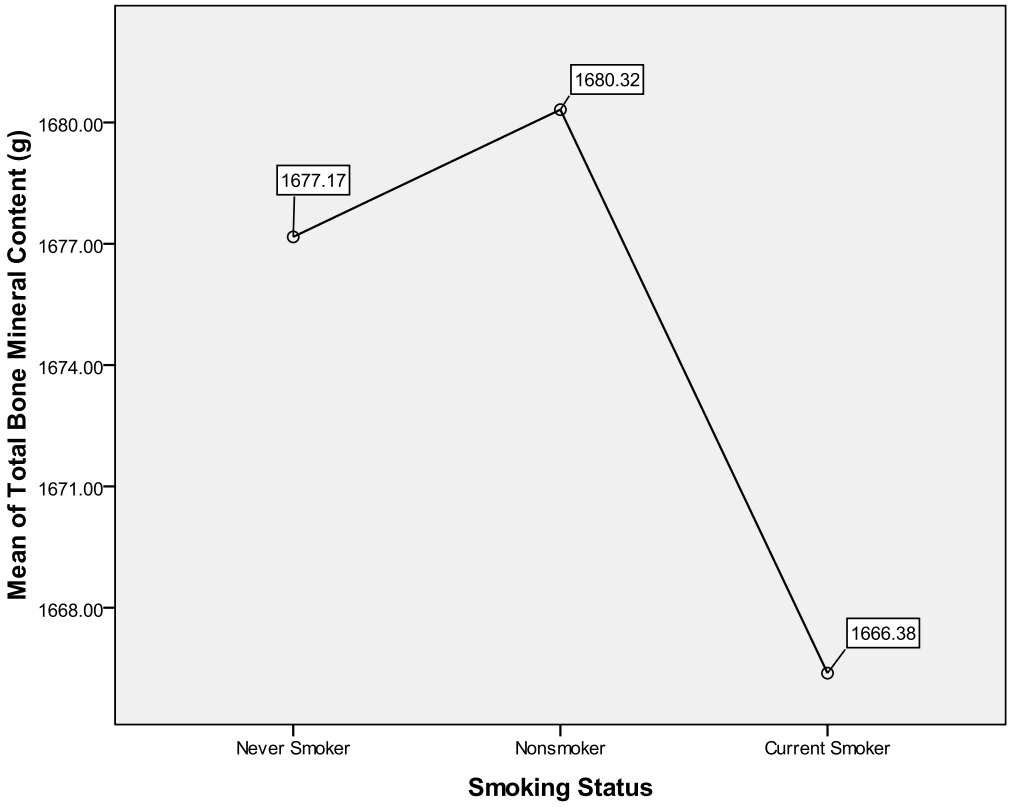
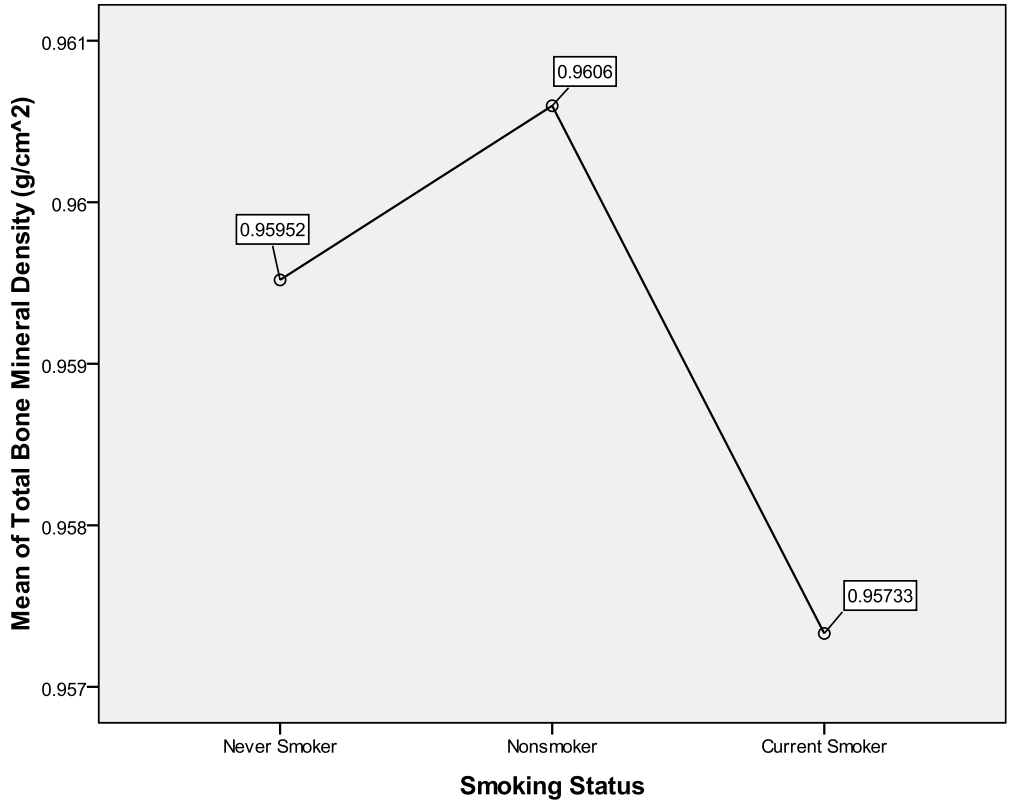


Figure 4: Mean BMD and Smoking Status in Hispanic Women*



Note: * Hispanic women in this study

Figure 5: Mean BMC and Smoking Status in All Women*

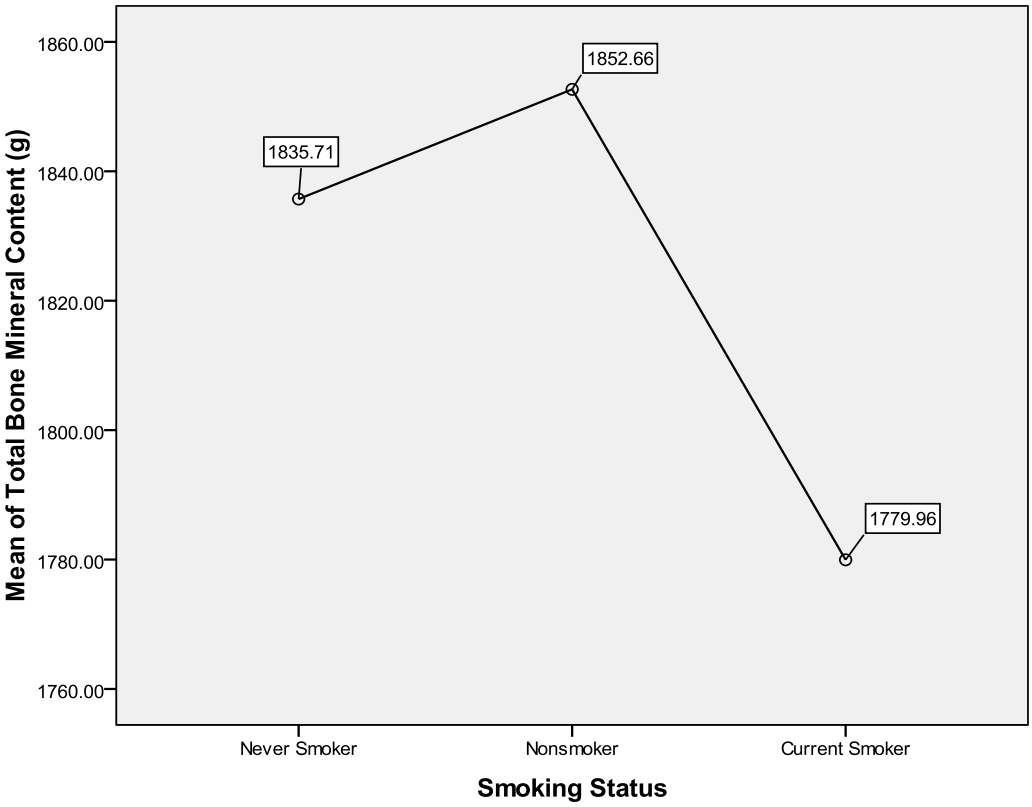
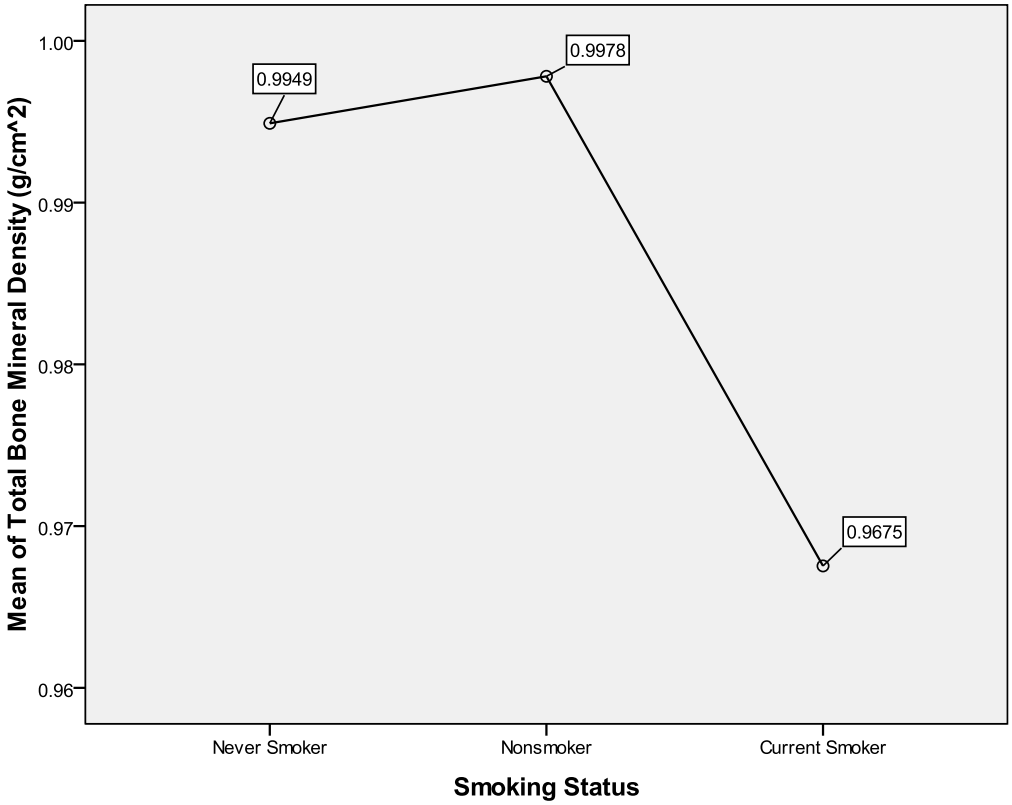


Figure 6: Mean BMD and Smoking Status in All Women*



Note: * All women in this study

An ANOVA was run for Hispanic women to compare mean values for BMC and BMD with respect to smoking status, see Table 4. Based on this test there was no significant difference in BMC in regards to smoking status ($F_{2,591}$=.032, p=.968) or in BMD in regards to smoking status ($F_{2,591}$=.017, p=.984) for Hispanic women in this study. An ANOVA was also run for the total women comparing means for BMC and BMD with smoking status. According to the results for the overall women in this study, there was a significant difference in BMC ($F_{2,2433}$=3.959, p<.05) and a significant difference in BMD ($F_{2,2433}$=7.255, p<.05). This shows that overall for women in this study there is a significant difference between the three smoking status groups. A significant difference was found for the overall women in this study, but not for Hispanic women in this study with regards to BMC and BMD and smoking status.

Table 4

ANOVA: Smoking and BMC, BMD

		Hispanic Women**					All Women**				
		Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.
Total Bone Mineral Content (g)	Between Groups	7171.537	2	3585.769	.032	.968	990877.811	2	495438.905	3.959	.019*
	Within Groups	6.613E7	591	111895.633			3.044E8	2433	125126.671		
	Total	6.614E7	593				3.054E8	2435			
Total Bone Mineral Density (g/cm^2)	Between Groups	.000	2	.000	.017	.984	.185	2	.092	7.255	.001*
	Within Groups	7.177	591	.012			30.941	2433	.013		
	Total	7.178	593				31.126	2435			

Note: * Significant at the 0.05 level
** Hispanic women and all women in this study

A Tukey HSD Post HOC test was run between BMC and BMD with smoking status to compare pairs, see Table 5. For Hispanic women in this study it was found that there are no significant differences between BMC or BMD and smoking status. When comparing the total

women in this study, there was a significant difference found between the mean BMC of nonsmokers and current smokers ($p=.014$). After evaluating never smokers and current smokers in women overall, it was found that there was some significance ($p=.056$) but not at the level of $p<.05$. In the same group of women, comparing mean BMD to smoking status, there was a significant difference between never smokers and current smokers ($p=.001$) and a significant difference between nonsmokers and current smokers ($p=.001$). When looking at the total women in this study over 60 with a BMD greater than or equal to zero, it was found that current smokers have a significantly lower BMC and BMD than nonsmokers and never smokers.

Table 5

Tukey HSD Post HOC Test: Multiple Comparisons between Smoking and BMC, BMD

Dependent Variable	(I) Smoker	(J) Smoker	Hispanic Women** Mean Difference (I-J)	Hispanic Women** Standard Error	Hispanic Women** Sig.	All Women** Mean Difference (I-J)	All Women** Standard Error	All Women** Sig.
Total Bone Mineral Content (g)	Never Smoker	Nonsmoker	-3.14611	32.14875	.995	-16.95183	15.95253	.537
		Current Smoker	10.78809	50.65717	.975	55.75189	24.23806	.056
	Nonsmoker	Never Smoker	3.14611	32.14875	.995	16.95183	15.95253	.537
		Current Smoker	13.93420	55.08686	.965	72.70372	25.84841	.014*
	Current Smoker	Never Smoker	-10.78809	50.65717	.975	-55.75189	24.23806	.056
		Nonsmoker	-13.93420	55.08686	.965	-72.70372	25.84841	.014*
Total Bone Mineral Density (g/cm^2)	Never Smoker	Nonsmoker	-.00108	.01059	.994	-.00291	.00509	.835
		Current Smoker	.00219	.01669	.991	.02736	.00773	.001*
	Nonsmoker	Never Smoker	.00108	.01059	.994	.00291	.00509	.835
		Current Smoker	.00327	.01815	.982	.03027	.00824	.001*
	Current Smoker	Never Smoker	-.00219	.01669	.991	-.02736	.00773	.001*
		Nonsmoker	-.00327	.01815	.982	-.03027	.00824	.001*

Note: * The mean difference is significant at the 0.05 level
** Hispanic women and all women in this study

Calcium in relation to BMC and BMD was another main focus of this study. It was found that 90.6% of the total women in this sample did not meet their recommended dietary intake of calcium and only 9.4% meet their daily needs. A Pearson correlation was used to determine the strength of association between BMD and calcium intake. A significant positive correlation was observed between total BMD and calcium intake for Hispanic women in this

study (p=.002). The same test was run for the total women in this study and a significant positive correlation was also noted between total BMD and calcium intake (p=.012). It was found that Hispanic women in this study have a stronger correlation between BMD and calcium intake than the total women in this study, see Table 6.

Table 6

Correlations: Calcium and BMD

		Hispanic Women***		All Women***	
		Calcium (mg)	% of Calcium (mg) - AI	Calcium (mg)	% of Calcium (mg) - AI
Total Bone Mineral Density (g/cm^2)	Pearson Correlation	.130**	.130**	.052*	.052*
	Sig. (2-Tailed)	.002	.002	.012	.012
	N	569	569	2345	2345

Note: * Correlation is significant at the 0.05 level (2-Tailed)
** Correlation is significant at the 0.01 level (2-Tailed)
*** Hispanic women and all women in this study

The mean BMC and BMD were compared to calcium intake in both Hispanic women in this study and the overall women in this study; see Table 7 and Table 8. When comparing the mean total BMC in Hispanic women in this study for those meeting the daily recommended intake for calcium and those not meeting it, by way of a T-Test, the means are relatively close with "not met" at 1668g and "met" at 1770g. With equal variances assumed there is a 2-tailed significant difference in the average BMC in Hispanic women in this study depending on whether or not they meet the required daily intake of calcium (T_{567}=-2.180, p=.030). When comparing the mean total BMD in Hispanic women in this study for those meeting the daily recommended intake for calcium and those not meeting it, by way of a T-Test, the means are relatively close. Average BMD for Hispanic women in this study who met daily calcium intake requirements was .9984g/cm^2 compared to .9554g/cm^2 for those who did not meet the daily requirements. With equal variances assumed there is a 2-tailed significant difference in the

average BMD in Hispanic women in this study depending on whether or not they meet the required daily intake of calcium (T_{567}=-2.779, p=.006). For Hispanic women in this study there is a stronger significance between calcium intake and BMD than between calcium intake and BMC. A T-Test was also run for the total women in this study, comparing BMC and BMD with calcium intake. Average BMC for the women in this study overall who met daily calcium intake requirements was 1840g and 1835g for those who did not meet the daily requirements. There was no significant difference in the average BMC for the women in this study overall depending on whether or not they meet the required daily intake of calcium (T_{2343}=-0.180, p=.857). Average BMD for the total women in this study who met daily calcium intake was .9926g/cm^2 compared to .9931g/cm^2 for those who did not meet daily requirements. There was no significant difference in the average BMD for the total women in this study depending on whether or not they meet the required daily intake of calcium (T_{2343}=0.064, p=.949).

Table 7

Group Statistics: Calcium and BMD, BMC

		Hispanic Women*				All Women*			
	Meet Calcium (mg) - AI	N	Mean	Std. Deviation	Std. Error Mean	N	Mean	Std. Deviation	Std. Error Mean
Total Bone Mineral Content (g)	Not meet Calcium (mg)	513	1668.001	333.835	14.739	2109	1835.779	356.711	7.767
	Met Calcium (mg)	56	1770.623	340.494	45.500	237	1840.155	341.534	22.203
Total Bone Mineral Density (g/cm^2)	Not meet Calcium (mg)	513	.9554	.11003	.00486	2109	.9931	.11425	.00249
	Met Calcium (mg)	56	.9984	.11024	.01473	237	.9926	.10730	.00698

Note: * Hispanic women and all women in this study

Table 8

T-Test Independent Samples: Calcium and BMD, BMC

	Hispanic Women**					All Women**				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Total Bone Mineral Content (g)	-2.180	567	.030*	-102.622	47.074	-.180	2343	.857	-4.376	24.353
Total Bone Mineral Density (g/cm^2)	-2.779	567	.006*	-.04304	.01549	.064	2343	.949	.00050	.00779

Note: * Significant at the 0.05 level.
** Hispanic women and all women in this study

DISCUSSION

Obtaining medical information for Hispanic women is important due to the recent increase of Hispanics in the United States' population. Much of the health data, including osteoporosis, is limited to non-Hispanic White women. It is important to discover if these health statistics can be generalized to other ethnical populations, or if there are differences between the populations. The results found in this study correspond to those found in the literature. When looking at the total women in this study above the age of 60, with a BMD greater than or equal to zero, it was found that current smokers have a lower BMD than those who never smoked or those who quit smoking. This study demonstrated the same relationship between BMD and smoking status in Hispanic women in this study, although this was not as great of a difference. The literature shows that smoking decreases BMD in postmenopausal women by 13 percent when compared to non-smokers as a result of decreased calcium absorption and increased bone resorption (Rapuri et. al. 2000). After looking at BMC and BMD mean plots, it was determined that smoking cessation appears to have a positive effect on BMC and BMD levels. Nonsmokers,

or those that quit smoking, had the highest average BMC and BMD in both Hispanic women and total women in this study. This effect could result from lifestyle changes at the time of smoking cessation or result simply from the population that was chosen to be included in the sample. The literature agrees that men and women who smoke have an increased risk of bone loss and reduced BMD which may cause an increase in fractures later in life; the literature also states that smoking cessation may have a positive effect on limiting the bone loss caused by smoking (Hollenbach et. al. 1993). Although fractures were not examined in the present study, a decreased BMC or BMD can increase the risk for fractures and smoking can diminish BMC and BMD. According to the literature, a history of smoking was associated with an increase in fractures, specifically those related to osteoporosis or hip fracture (Kanis et. al. 2005). Smoking was shown to decrease BMC and BMD and smoking cessation can help to improve BMC and BMD overall in women and Hispanic women in this study. According to the literature by Evans and Taylor (2006), multiple factors influence the risk for osteoporosis and risk for fractures. The present study did not look at all ecological factors relating to osteoporosis, but did look at calcium consumption and smoking in relation to BMC and BMD.

This study found that the majority of women (90.6% of total women in the study) do not meet the daily recommended calcium intake. Although this study did not look at education of women on osteoporosis prevention, it can be concluded that more women need to be informed about adequate calcium intake to ensure that they can try to prevent osteoporosis and a loss of BMC and BMD in life. The literature supports this by stating that more education of osteoporosis prevention needs to be provided to all women (Larkey et. al. 2003). The present study shows that there is a significant positive correlation between BMD and calcium intake overall in women in this study; this relationship is more significant in Hispanic women in this

study. It is important for Hispanic women to have an adequate intake of calcium because the results showed the correlation between BMD and calcium intake was stronger for Hispanic women in this study. The literature states milk intake at the time of childhood and adolescence is associated with adult bone mass, BMD, and the occurrence of osteoporotic fracture. Children with a higher calcium intake have been known to increase their peak bone mass, thereby reducing their chance of osteoporosis (Kalkwarf et. al. 2003). The current study suggests that a higher intake of calcium can lead to a higher BMD overall for women in this study, and is more evident for the Hispanic women in this study.

This study has some limitations that may have affected the results. NHANES oversampled the elderly and Hispanic population to ensure that minorities were represented; this overrepresented the elderly and Hispanic population in the United States. When the NHANES data was limited to Hispanic women over the age of 60 with a BMD greater than or equal to zero, the sample size was only 595, which was relatively small. In this study, the sample was weighted to more accurately represent the elderly and Hispanic population in the United States. Weighting the sample allowed for greater external validity; however, other factors in this study limit the generalizability. One threat to internal validity includes the DEXA data from NHANES. The DEXA data was collected by NHANES and people were contracted to analyze the results. There was no standardized method implemented to analyze the DEXA results, so the data was compiled in various formats. Total body DEXA provides a summation of the measured total body BMD and BMC, and is not typically used for diagnosis of osteoporosis (Bonnick and Lewis, 2006, p. 296). Hip and spine DEXA results would be a more accurate way to measure BMD and BMC for diagnosis of osteoporosis; however these results were not included in the data collected from NHANES. Another limitation included the smoking questionnaires; the

questionnaires for the three different time periods had different questions numbers with the same question and answer choices. The questions had to be renumbered in order to merge the questionnaires. A limitation of the participants included memory bias; this is unavoidable when asking the participant to recall information. In order to reduce the number of non-response errors in the study, and thereby increasing the internal validity, answer options included "don't know" and "refused". With the limitations of this study, it is difficult to generalize the results to Hispanic women over the age of 60 years outside of this study.

This study shows many significant results regarding osteoporosis and Hispanic women. It can be concluded that smoking contributes to a decrease in BMC and BMD overall for women in this study. This occurs in Hispanic women in this study also, however, it is not as strong of a correlation. Smoking cessation has been associated with improved BMC and BMD in Hispanic women in this study and in total women in this study. An increase in calcium consumption is shown to lead to a higher mean BMD in Hispanic women in this study and overall in women in this study. Further research should be done regarding Hispanic women and osteoporosis, and allow for more education to be provided to all women regarding osteoporosis prevention. A future study should be done to look at the prevalence of osteoporosis in Hispanic women using DEXA data from the spine and hip. Other studies could focus on calcium supplements, exercise, or other factors relating to osteoporosis. Each study is important to the health community because each ethnic population is unique in their health concerns and different studies may show statistics that were previously unknown.

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APPENDIX A

QUESTION NUMBERS AND LABELS FOR SMOKING QUESTIONNAIRE

Question Label	1999-2000 Question Number*	2001-2002 Question Number	2003-2004 Question Number	Adjusted Question Number
Smoked at least 100 cigarettes in life	SMQ020	SMQ020	SMQ020	SM20
Age started smoking cigarettes regularly	SMD030	SMD030	SMD030	SM30
Do you now smoke cigarettes	SMQ040	SMQ040	SMQ040	SM40
How long since quit smoking cigarettes	SMQ050Q	SMQ050Q	SMQ050Q	SM50A
Unit of measure (day/week/month/year)	SMQ050U	SMQ050U	SMQ050U	SM50B
Number of cigarettes smoked per day now	SMD070	SMD070	SMD070	SM70
How many years smoked this amount	SMD075	SMD075	SMD075	SM75
Number of days smoked cigs (sic) during past 30 days	SMD080	SMD080	SMD641	SM80
Average number of cigarettes/day during past 30 days	SMD090	SMD090	SMD650	SM90
FTC Tar Content	SMD100TR	SMD100TR	SMD100TR	SM100TR
FTC Nicotine Content	SMD100NI	SMD100NI	SMD100NI	SM100NI
FTC Carbon Monoxide Content	SMD100CO	SMD100CO	SMD100CO	SM100CO

Note: *The data is in the SPSS dataset but it is not listed in the codebook.